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JOURNAL
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VOL. 49 MARCH 1959 No. 3

PAPERS COMPRISING A SYMPOSIUM ON THE SUBJECT "EXTRAMURAL SCIENCE PROGRAMS OF THE FEDERAL GOVERNMENT," ARRANGED BY A COMMITTEE OF THE WASHINGTON ACADEMY OF SCIENCES (GEORGE W. IRVING, CHAIRMAN) AND PRESENTED SUNDAY MORNING, DECEMBER 28, 1958, AT THE SHERATON-PARK HOTEL, WASHINGTON, D. C., AS THE ACADEMY'S CONTRIBUTION TO THE 125TH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Introductory Remarks by Dr. A. T. McPherson, Presiding

It is a great pleasure for me, as the President of the Washington Academy of Sciences, to welcome you to the symposium on "Extramural Science Programs of the Federal Government." This symposium is the Washington Academy's contribution to the 125th meeting of the American Association for the Advancement of Science. As you know, Washington is the scientific as well as the political Capital of the United States. Every major scientific activity in our Government has its headquarters in or nearby Washington. Moreover, several of the national scientific societies have established their national headquarters here in Washington, owing at least in part to their desire to be near the scientific activities being conducted here at the seat of Government. Among these is, of course, our own Association.

Since Washington is unique in being the center of Federal scientific activity, it was felt in planning this symposium that our most useful contribution would be to have representatives of the principal agencies of the Federal Government describe some aspect of the research supported by them. Inasmuch as many who attend the AAAS meetings have conducted research under Federal support or may wish to, it occurred to us that the aspect that would be of most interest to the greatest number would be the extramural science programs each agency sponsors. It is particularly appropriate, we feel, that the Washington Academy of Sciences has been given the opportunity to do this since it is the one scientific society in the Nation's Capital that counts among its membership representatives of all the scientific disciplines. Included in its membership also are many of the policy-making scientists of the Federal Government.

Perhaps it is appropriate at the outset to indicate what we mean by "extramural" science programs. We mean, simply, any programs that are conducted outside of the physical facilities of an agency and staffed predominantly by non-Federal employees. This includes scholarships, fellowships, grants, grants-in-aid, loans, contracts and cooperative programs.

It would be impossible in the time allotted this session to include a description of every extramural program that is now in effect in the Federal Government. We have selected, rather, the six Federal agencies which, together, support the majority of extramural

research and science education programs in the country. They are, as your program indicates, the National Science Foundation, the National Institutes of Health, the U.S. Department of Agriculture, the Department of Defense, the Atomic Energy Commission, and the National Aeronautics and Space Administration. The representatives of these agencies here with us today can speak authoritatively on the extramural programs for which their agencies are responsible, since they occupy in each case high positions in their respective agencies.

The order of presentation is immaterial except for the first. We have asked the representative of the National Science Foundation to lead off since the NSF, in addition to its responsibility for its own direct extramural programs, has certain coordinating responsibilities for science programs in all Federal Government agencies as well.

We hope that this symposium will give you a clear picture of the extramural research and science education program of the Federal Government in its entirety.

Extramural Science Programs of the National Science Foundation

By ROBERT B. BRODE, *Associate Director for Research, National Science Foundation*

We are here as representatives of several of the Federal agencies to discuss the nature and scope of our respective agencies' extramural programs for research and education in science. The National Science Foundation conducts no research or education programs itself. All the support of education and research by the Foundation is through extramural grants and contracts.

The nature of the activities of the Foundation and its objectives are adequately described in the Act of Congress which was approved by the President in May 1950 and led to the establishment of the National Science Foundation as an independent Federal agency. Section 3 of this Act states that the Foundation is authorized and directed "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences; to initiate and support basic scientific research . . .; to appraise the impact of research. . . ."

In carrying out these directives the Foundation is itself forbidden to operate any laboratories or pilot plants. The Act permits the making of contracts or grants for scientific research through the utilization of appropriations available in such a manner as will best realize the objectives of the Foundation. There is very great freedom given to the Foundation in the choice of organizations or institutions to which grants or contracts may be given. While nonprofit organizations are particularly identified, the Foundation is not exclusively restricted to this type of agency. It may make grants to such institutions, individuals, agencies of the United States, and the several States as are qualified to best realize the objectives of the Foundation—in particular, the advance of basic research.

A very substantial part of the business of the National Science Foundation is the support of basic research in science through institutions and individuals that are best qualified to pursue such research. Advisory panels and program officers of the Foundation consider many factors in assessing research proposals: the qualifications and promise of the investigator; the nature of the proposed research project; and the facilities and support provided by the institution.

The Foundation is very conscious of the outstanding contributions made by a small number of scientists with exceptional ability. These men, together with a much larger number of good but not remarkable workers, will create the new developments in basic science. The Foundation is constantly looking for the young scientist who shows signs of real originality and boldness in his approach to scientific research.

In some areas of research the scientist's needs are easily met—books, pen, and paper may satisfy the mathematician. In most fields, however, the success of basic research in science depends on the accessibility of the necessary tools and assistants. Some of the modern research facilities are very costly and require large staffs of scientists and technicians for their operation. Nuclear reactors, cyclotrons, computers, radio and optical astronomy observatories have been built in part or wholly by Foundation grants.

In addition to providing the equipment required, Foundation support of research projects provides employment opportunities as research assistants for more than 6,000 graduate students studying for the Ph.D. degree.

Most of the basic research in this country is carried forward by our colleges and universities. It is therefore not surprising that nearly all the Foundation support of basic research is given to institutions of higher learning. This support is provided in almost every case through the use of a grant rather than by a contract.

In addition to its support of basic research, the Foundation supports a substantial program for the promotion of education in the basic sciences. The Foundation is directed by Congress to develop and encourage a national policy for the promotion of education in the sciences and in particular to award scholarships and fellowships. The award of fellowships to graduate students appears to have been an unusually successful enterprise, and thousands of scientists have been assisted by this program. Fellowship support has been extended to postdoctoral research workers and even to junior and senior faculty to assist them in developing new research programs or to enhance their competence as teachers. The competition for National Science Foundation fellowships is severe, and the award of a fellowship is considered as recognition of very high scholastic achievement and research promise.

Foundation support of education in the sciences extends to universities and colleges in all States through establishment of science teacher institutes. These are designed to improve the training of science teachers, especially secondary-school teachers, in the subject matter of science. Approximately 350 summer institutes will be functioning under this program in the summer of 1959. In addition, about 35 academic year institutes will begin in the fall of 1959, as well as some 200 in-service institutes designed to benefit the teacher who lives in the vicinity of the college or university by offering courses taught at night or on Saturdays.

The Foundation has developed several experimental programs in education; most of these are built upon patterns established either by the fellowship or the institute program. The Foundation is also extending substantial support to curriculum improvement programs for secondary-school science courses, in physics, mathematics, chemistry, and biology, but extending as well to many of the other sciences.

Knowledge is society's most precious possession, and a very important and rapidly growing area of knowledge is basic science. The value and use of knowledge can be assured for future generations only if we record in publications the results of our research. The critical problem of scientific literature is illustrated by the tremendous volume that must be assimilated. If the auditorium were full, all of the people in this room reading 24 hours a day could not keep up with our present output of scientific literature. The rate of increase of literature is such that the world's output in pages per year will double in the next 8.5 years. The National Science Foundation has contributed substantially to this flood of scientific literature by making grants to scientific societies to aid in the establishment of new journals or in the expansion in size of existing publications. The importance of Soviet scientific developments has been recognized in our program for English translations of important journals and books that are available only in the Russian language.

Not only is it necessary to print and store in our libraries the full account of our total knowledge, but we must also develop the means of identification and retrieval of this knowledge. We are assisting abstract journals as well as general studies of new means of searching for information. The Office of

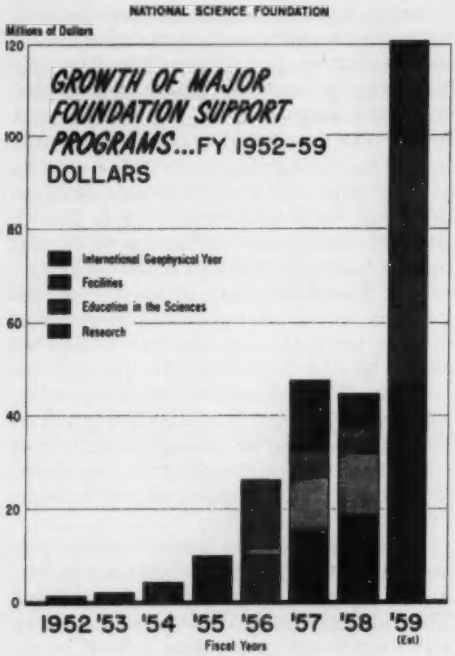

CHART 1

Science Information Service is a division of the Foundation that provides assistance and coordination to Government and private abstracting and information-handling services. It is not a Government office set up to answer requests of the general public or of Government agencies for information about specific technical questions.

There have been two events since the initiation of the Foundation in 1950 which have appreciably changed the anticipated growth of Federal support for this agency. The International Geophysical Year, which officially ends next Wednesday, has been an intensive burst of scientific effort with a year of preparation and an 18-month year of coordinated observations. For some years to come the results and deductions from this period of observation will be published in scientific journals. The second event that affected the Foundation's budget was the awakening of the world by the Russian Sputnik. We have suddenly realized that leadership can be substantially influenced by the intellectual and technical attainments of a nation. This leadership requires not only adequate support for the research of its talented scholars but also an educational system that identifies potential scholars and gives them the best possible preparation for their careers. Chart #1 shows the growth and magnitude of the support given the Foundation.

The National Science Foundation makes grants to scientists on the basis of proposals submitted to it and reviewed by panels of specialists and by the Foundation's program offices. Some of these grants assure support for three to five years, while others are for one or two years. The funds provided by Congress have only been sufficient to enable the Foundation to grant less than a third of the proposals it receives. It is quite natural that the scientist who has won the competition for an award will return after a year or two for further support and he will then, because of the greater opportunity provided by the Foundation funds, present an even better justification for his support. The percentage of proposals for research support to which grants were awarded is shown in Chart #2. This is by no means an established pattern of support. Many meritorious proposals are now refused grants. At times we have been able to grant less than one-third of the requests considered worthy of support by the review panels.

The use of substantial funds by the Foundation has enabled it to support the construction of such facilities as the National Radio Astronomy Observatory, Green Bank, W. Va., and the Kitt Peak National Observatory, Tucson, Ariz. These national laboratories and institutes carry with their creation an implied commitment for continued operating budgets. The Foundation is indeed concerned with the problem of providing adequate support for the major facilities, and for the continued support of able scientists who justify essentially life time support. To this committed support load must be added the encouragement and opportunity which the Foundation must be prepared to offer to the young scientist beginning his independent research activity.

Congress has directed that the Foundation avoid undue concentration of research and education activities. A measure of the

needs for basic science research support may be indicated by the number of graduate students or by the dollar grants. Chart #3 shows that the grants given are in reasonable balance with these two measures of need.

Support for education through fellowships and institutes for teacher training has been nationwide but not in all cases as well distributed as would be desired for a nationwide program. We have attempted to correct these discrepancies as they are iden-

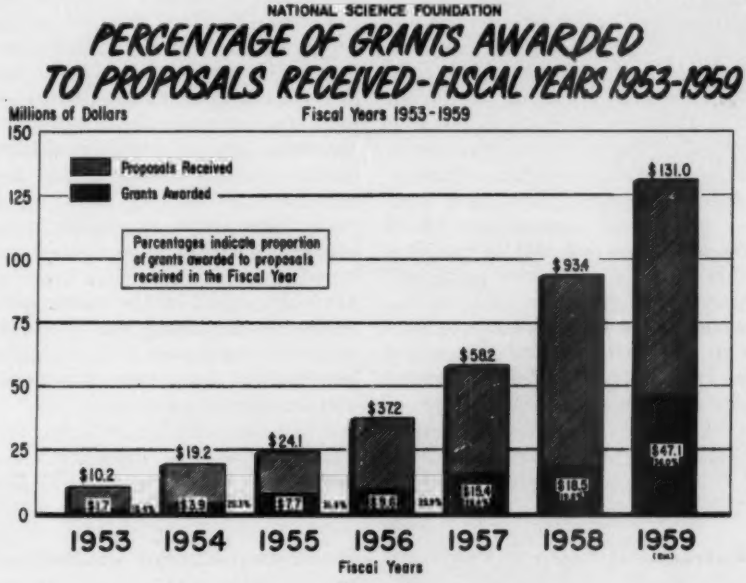

CHART 2

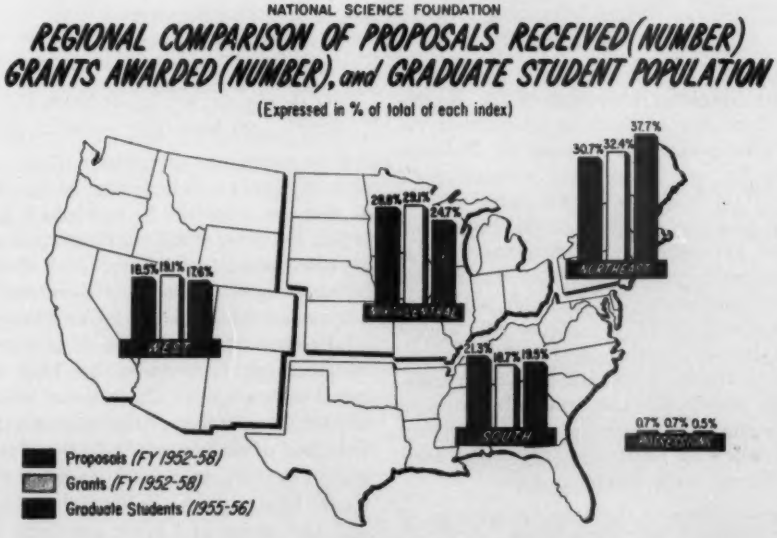

CHART 3

tified. A program of cooperative fellowships is being introduced this year which will provide a much wider distribution of fellows throughout the Nation, but still permit the applicant to select freely the institution through which he seeks to compete for the fellowship.

The activities of the Foundation are not restricted entirely to this country. Fellowships are granted only to citizens, but they may use their grants for study at foreign universities. Funds in support of research have frequently been used by grantees to carry on their studies in foreign countries; and in exceptional cases grants have been made to a few foreign investigators whose work was considered essential to our own programs or involved the active participation of American scientists or students. We have responsibilities for assistance to participants in international conferences and congresses. In our Office of Science Information Service we arrange for the exchange of publications and for the translation of some of these so that they will be generally available to scientists.

The principal objective of the National Science Foundation is the development of basic science in the United States. We are attempting to do this by direct support of the scientist in his research program, by supplying him with the means of publishing his results, with ready access to the results of the work of other scientists, and by improving our educational system so that promising scholars are given a better foundation for their future careers. Some very valuable and exciting advances have already been made in science through our support, but the major impact of such a broad program as we have undertaken will not be measured by the visible splashes but rather by the rising tide of general basic science development and the technological benefits that later come to society through their application and use.

Extramural Science Programs of the Department of Defense

By GEORGE D. LUKES, *Executive Secretary, Defense Science Board, Office of the Director of Defense Research and Engineering*[1]

I appreciate the invitation of the Washington Academy of Sciences to participate in this symposium and to make the Defense contribution on extramural science programs of the Federal Government. We in Defense find a symposium of this nature an excellent opportunity to get across to the scientific community at large the nature and scope of our scientific research activities and, particularly in the theme of today's session, how our extramural activities contribute to the achievement of Defense objectives. Within this framework I shall also weave some of the more significant aspects of our policy on basic research in the hope of furthering understanding.

[1] Formerly Office of the Assistant Secretary of Defense (Research and Engineering).

DOLLAR MAGNITUDE, PERFORMANCE COMPONENTS, AND RESEARCH SUPPORT LEVELS

It is important to provide, first, a backdrop of the total dollar effort of Department of Defense scientific research and development. The first chart shows graphically the DOD obligations for fiscal year 1959 in relation to those of the other Federal Government agencies. Something like 62 percent of all Federal funds devoted to research and development represents the Defense Department's share of the Federal effort. The second chart displays the approximate distribution of these funds in terms of the three major performance components: Government laboratories, industrial contractors, and university and other nonprofit institu-

tions. You will note that industry performs about 60 percent of the total effort supported from the research and development appropriations of the Department of Defense, universities and other nonprofit institutions conduct about 9 percent, and Government laboratories perform the balance of 31 percent. Of funds for in-house performance, approximately 14 percent is for research and development *per se* conducted internally by Government scientists and engineers, 13 percent is for test and evaluation, and 4 percent is for contract monitoring.

I should now hasten to add that an additional source of funds is available for support of scientific and engineering activities of the Department of Defense, primarily the latter. These, in appropriation language, are principally the Procurement and Production funds, of which something like $3.2 billion in fiscal year 1959 go to the support of development, test, and evaluation of new weapons of the distinctively hardware variety—the B-58 and the IRBM and ICBM programs are good examples. The charts presented do not include the funds from this source; within the theme of this symposium—extramural science—their omission is of little consequence, however.

Now let us discuss the scientific research activity of the Defense effort. The third chart displays the character distribution of the Defense research and development program. Of our fiscal year 1959 research and development programs, 15 percent, or $391 million, is devoted to research; and of this $109.6 million is for basic research. The balance, 85 percent of the total program, is for development. We estimate that almost two-thirds of the $391 million of research funds supports extramural activities, and at least 70 percent of the $109.6 million basic research funds is devoted to extramural support of basic research.

NATURE AND SCOPE OF DEFENSE SCIENTIFIC RESEARCH ACTIVITIES

The science programs of the Department of Defense comprise activities in the physical and engineering sciences, in the life sci-

CHART 1. Estimated Distribution of FY 1959 Federal Government Research and Development Obligations.

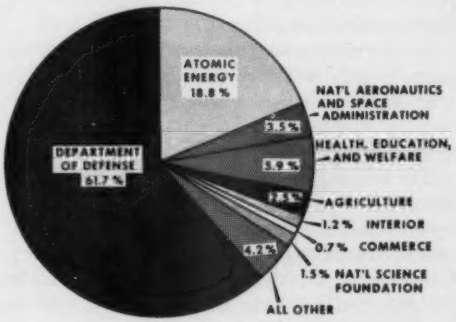

CHART 2. Where Defense Research and Development is Performed.

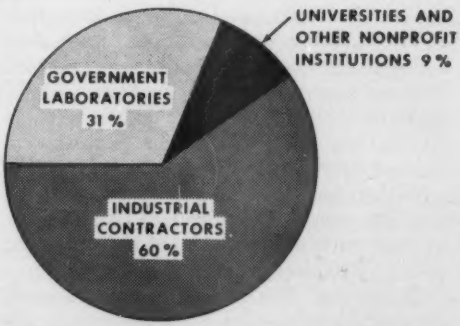

CHART 3. Character of Defense Research and Development Program for FY 1959.

ences, in psychology and the social sciences, and in operations research.

About 80 percent of the funds devoted to scientific research support activities in the physical and engineering sciences; this amounts to about $313 million in fiscal year 1959 Defense program. Within this broad category the typical fields of endeavor and the program objectives are as follows:

In *physics* the objective is the advancement, through systematic and exploratory research, of those selected aspects of pure and applied physics which contribute to an increase in military capability. The present program, totaling about $33 million in extramural effort, includes solid-state physics, extreme-temperature physics, statistical physics, physics of atoms and molecules, nuclear physics, physical acoustics, upper-air physics, electron physics, optics, magnetism, instrumentation for physical measurements, and electromagnetic radiation.

In *chemistry* the objective of the program may be divided into two parts: (1) a balanced effort of selected fundamental research which serves as a foundation for the varying needs of the military and (2) specific applied projects aimed at satisfying short-term defense needs. The present program includes research support in relevant areas of analytical, inorganic, organic, physical, polymer and radiation chemistry. The extramural support runs about $31 million yearly.

In *mathematics* the objective is the systematic advancement of this science, closely geared to the objectives of the other scientific programs, and in response to expanding needs for direct qualitative information about the design and operations of weapons and weapons systems. The present program includes algebra, analysis, geometry, topology, probability, statistics, logistics, communications, and computers. Extramural support runs about $5 million yearly.

With respect to those fields of endeavor that are more characteristically the engineering sciences, the scope of the programs and the broad objectives are as follows:

Mechanics: The objective of the research program in mechanics is the systematic advancement of engineering knowledge and principles bearing directly upon design criteria for the development of new weapons systems and components. Studies on the following are included in the present program: the dynamics of gases, liquids and solids; aerodynamic problems; problems involving structural design, strength of solids, hydromechanics, propulsion, heat and mass transfer, soil mechanics; and problems involving the development and synthesis of mechanisms. Extramural support runs about $25 million yearly.

Materials: The objective of the research program is the systematic advancement of knowledge on the fundamental properties and behavior of materials to provide the best possible selection for designers and fabricators of military weapons and equipments. The present program includes studies on metals, minerals, ceramics, elastomers, adhesives, transparent materials, organic structural materials, fibers and fibrous materials, insulating materials, and dielectric and magnetic materials. Extramural support runs about $27 million yearly.

Combustion: The objective of the research program in the field of combustion is to gain an increased understanding of the total process of transforming the chemical energy of reactants into thermal and kinetic energy of reaction products, so the design of military propulsion devices can be put on an increasingly rational basis. The present program includes investigations of basic phenomena in selected areas of physics, chemistry, fluid mechanics, thermochemistry, and thermodynamics; and also fundamental investigations of processes that are interrelated combinations of these phenomena. Extramural support runs about $6 million yearly.

Electronics: The objective of the research program in electronics is to ensure maximum extension and acceleration of all our senses for military purposes. The present program includes acoustics and underwater sound; antenna theory, electromagnetic propagation and reflection; communications, data handling, and information theory; electronic instrumentation and standards; electronic countermeasures and counter-countermeasures; IFF theory; infrared; navigation; radar; electronic tubes, parts, and semiconductors; and electron and

ion plasma. Extramural support runs about $43 million yearly.

In the *geophysical sciences* the objective is the advancement through systematic and exploratory research of those selected aspects which will increase the capability of the military to utilize, predict, and control the natural environment. Included in the present program are meteorology, climatology, oceanography, marine geology, geochemistry, cartography, geodesy, geography, astronomy, astrophysics, magnetism, and gravity studies. Extramural support runs about $19 million yearly.

Turning now to the broad category of life sciences, the DOD supports major programs in the medical sciences and in biology. The scope and the objectives are:

In the *medical sciences*, to provide support of the mission of military medicine by studies in—

(a) Preventive medicine: research on methods of physical examination and health surveillance, promotion of physical fitness, preventive dentistry; nutrition, environmental physiology and pathology, disease and injury prevention, toxicology; protection against radiation and blast, the effects of chemical and biological agents, with methods of casualty prevention; industrial and public health studies.

(b) Studies relating to the medical problems of aviation, astronautics, submarine and diving medicine, man in relation to the machines of war in all media, terrain and climates; and survival techniques.

(c) Improved methods of medical, surgical, dental and psychiatric care and rehabilitation of the sick and injured.

The medical sciences program runs about $24 million yearly, of which about $15 million is the extramural effort.

In the *biological sciences* the objective is the systematic development of this field in areas of military interest. The present program includes hydrobiology, biogeography, ecology, the biomechanism of complex data reception and control in living systems, bacterial fungal, viral genetics and nutrition, the ecology of disease vectors, the mechanism of infection, and the survival of microorganisms. Extramural support runs about $7 million yearly.

As to the *psychological and social sciences*, the support level is about $21 million, of which $15 million is the extramural effort. Program content and the objectives are: the advancement through systematic and exploratory research of those selected aspects of pure and applied psychological and social sciences which contribute to an increase in the military capability. The present program includes studies leading to new concepts, techniques, devices, and principles applicable to the solution of military problems, including military manpower needs and the availability, selection, classification, assignment and proficiency measurement of personnel; education; training and training devices; motivation; morale; leadership; human organization; human engineering; psychological and unconventional warfare; intelligence operations; and civil affairs and military government.

Finally, coming to *operations research* as a field of scientific activity in its own right, the objective is to provide quantitative bases for executive decisions on military and related scientific matters. The present program includes contracts totaling about $28 million in support of work with RAND, the Operations Research Office, the Operations Evaluation Group, the Combat Operations Research Group, the Institute for Defense Analyses, the Human Resources Research Office, the Naval Warfare Analysis Group, and the Naval Warfare Research Center.

In total, these scientific research programs comprise a fiscal year 1959 Defense effort amounting to about $391 million, providing about $137 million to the conduct of intramural effort and $254 million to the support of extramural science activities.

DEPARTMENT OF DEFENSE POLICY ON BASIC RESEARCH

Let us turn now to objectives stated even more broadly. About a year ago Secretary McElroy issued a strong policy directive setting forth the principles governing the support of a Department-wide basic research program, conceived and anchored in imaginative long-term planning and long-term funding. This policy recognizes that "the needs of national defense are

uniquely characterized by pressing demands for new facts and knowledge very close to the frontiers of science" in order to protect the security of the United States and its vast Defense investment against both technological surprise and obsolescence. It emphasizes also that the costs of basic research are small in proportion to the potential military strength to which basic research is capable of contributing and that "sustained support of basic research offers one of the most promising opportunities for effecting long-range economies in other aspects of the military program."

Specifically, the directive states:

A. It is the policy of the Department of Defense:
   1. To support a broad and continuing basic research program to assure the flow of the fundamental knowledge needed by the military departments as prime users of scientific facts and to evolve novel weapons of war; and
   2. To maintain, through such a broad support program, an effective contact between the military departments and the scientists of the country so that the military departments are continuously and growingly aware of new scientific developments and the scientists are aware of the military needs.

B. It is further the policy of the Department of Defense to coordinate its basic research program with the National Science Foundation and to encourage the support of sound basic research programs by government and private agencies, recognizing that these programs are essential to the full development, utilization and growth of the nation's scientific resources and, hence, to national defense.

Within the guidance of this policy, the Department of Defense substantially increased fiscal year 1958 funding for some research programs judged critical for the improvement of military weaponry. The increased funding for each field was: $31.6 million for the physical, medical, and geophysical sciences; $10 million for materials research; and $12.5 million for the vital areas of electron tubes and electronic parts. $30 million of these funds went to the support of basic and supporting research programs at academic institutions. The main effect was to restore research to the level from which it had sagged over the past several years owing to inflation and the increased costs of modern instrumentation. In addition to the above funds, $12 million was made available to the Army and Air Force in June of this year for the explicit purpose of financing certain contractual research programs for periods longer than the annual program increment or to provide for program longevity.

NEW GRANTS AUTHORITY UNDER PUBLIC LAW 85-934

The recent session of Congress saw the passage of Public Law 85-934, an act to authorize the expenditure of funds through grants for the support of scientific research. Heretofore the Department of Defense has been limited to the use of a research contract in engaging the services of an educational or other nonprofit organization. The Grants Act provides the authority to make grants to such institutions or organizations for the support of basic scientific research, where such action is deemed to be in furtherance of the objectives of the agency; it also grants discretionary authority to vest title of research equipment in the organization carrying out such research. Increased flexibility will accordingly result from this authority in Defense support of basic scientific research. A directive is presently being drafted in the Department of Defense to establish a uniform policy among all military agencies in the awarding and administration of research grants and the transfer of title to research equipment acquired under such grants.

This, I believe, covers the highlights of Defense science programs and our broad objectives in their support, the program content and technical objectives of our scientific effort in some discrete fields, and certain aspects of Defense policies designed to be constructive, forward-looking, and to lend stimulation and sustenance to science from the Defense end of the Federal Government.

Extramural Science Programs of the National Institutes of Health

By C. J. VAN SLYKE, *Deputy Director, National Institutes of Health; Assistant Surgeon General, Public Health Service, U. S. Department of Health, Education, and Welfare*

It is a pleasure to appear in this symposium on the extramural science programs of the Federal Government.

The program chairman has asked that I cover briefly the objectives and nature of the National Institutes of Health with respect to our extramural activities, leaving time for questions and discussion. What I shall present, therefore, is a thumbnail sketch of the NIH grants and awards programs.

I shall not attempt to include the NIH intramural program—its conduct of research—nor all the extramural programs of the U. S. Public Health Service, of which the NIH constitutes the principal research branch. Nor will this outline cover extramural scientific activities of other components of the Department of Health, Education, and Welfare, in which the Public Health Service is a part.

Now to turn to the NIH extramural program. The objective of the National Institutes of Health and of the Public Health Service is contained in the public laws which form our enabling legislation and which impose upon us grave obligations and duties. The purpose of all our activities is stated, in simplest terms, in public law as being "to improve the health of the people of the United States."

The methods for achieving this objective are, again in the shortest words, the conduct and support of research and training and aid in the application of knowledge.

In the legislation upon general duties, there is a charge to "conduct in the (Public Health) Service, and encourage, cooperate with, and render assistance to other appropriate public authorities, scientific institutions, and scientists in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and impairments of man . . ."

In legislation establishing the Institutes which compose the NIH, such as the NHI, NCI, and so on, there are mandates directing the conduct and support of research and training and other activities aimed at the acquisition and application of knowledge concerning cancer and heart disease and other "categorical" disease fields.

Additionally, through the Health Research Facilities Act of 1956, there is provided a program of support for the construction of research facilities in the sciences related to health.

NATURE OF THE PROGRAM

These, then, are the objective and the methods of NIH extramural activities in general, legislative terms. What has been built upon this framework, what is it for, how does it operate, what are its characteristics, what is it accomplishing, what is its future? These and other broad questions occur, and the answers, though they be partial, will portray the nature of our grants and awards programs.

To begin the answers upon a historical note, I was privileged to author a paper, upon the real beginning of the NIH extramural program, in the issue of *Science* for Friday, December 13, 1946. The day and the date have turned out to be more auspicious than the general belief holds about enterprises connected with Friday the thirteenth. The paper began with these words:

> A large-scale, nationwide, peacetime program of support for scientific research in medical and related fields, guided by more than 250 leading scientists in 21 principal areas of medical research, is now a functioning reality. The program, based on U. S. Public Health Service Research Grants financed by public funds, supports research—conducted without governmental control—by independent scientists. The purpose of these grants is to stimulate research in medical and allied fields

by making available funds for such research and by actively encouraging scientific investigation of specific problems on which scientists agree that urgently needed information is lacking. Accompanying this purpose is complete acceptance of a basic tenet of the philosophy upon which the scientific method rests: The integrity and independence of the research worker and his freedom from control, direction, regimentation, and outside interference.

The U. S. Public Health Service Research Grants, in operation as a medical research program of scientists and by scientists, may have early and profound effects upon the course of medical history and the national health.

The program, both in principle and as administered, has been welcomed and approved wholeheartedly by leaders in medical research.

ORGANIZATIONS OF ACTIVITIES

The organization, programming, and appropriations responsibilities of the NIH extramural activities today fall into the following categorical Institutes and Divisions: National *Cancer* Institute, National *Heart* Institute, National Institute of *Allergy and Infectious Diseases*, National Institute of *Arthritis and Metabolic Diseases*, National Institute of *Dental Research*, National Institute of *Mental Health*, National Institute of *Neurological Diseases and Blindness*, *Division of General Medical Sciences*, *Division of Hospital and Medical Facilities*, *Division of Nursing Resources*, *Division of Sanitary Engineering Services*, and *Division of Special Health Services*. Noncategorical or general research and training grant funds are available from the Division of General Medical Sciences for scientists whose interest do not fall within the scope of responsibility of the categorical Institutes and Divisions. The Division of Research Grants of the National Institutes of Health has administrative responsibility for the management of the research grants programs, and for the Health Research Facilities construction grants.

NATIONAL ADVISORY COUNCILS

By Federal law, nine National Advisory Councils have been established as advisers to the Public Health Service. No research or training grant may be paid by the Surgeon General unless recommended for approval by one of these Councils. Seven of the Councils advise the seven so-called categorical Institutes on their respective programs, in addition to reviewing and recommending appropriate action on applications for grant support. The National Advisory Health Council reviews applications for general or noncategorical research grants and advises the Surgeon General on matters relating to health activities and functions of the Service. The Federal Hospital Council advises the Surgeon General on matters relating to the Administration of the Hospital Survey and Constructions Program and reviews applications for grants in aid of projects in research, experiments, or demonstrations relating to the development utilization, and coordination of hospital services, facilities, and resources.

The National Advisory Council on Health Research Facilities, established in July 1956, reviews and recommends appropriate action on applications submitted by universities or other nonprofit institutions for assistance in the construction and/or equipping of additional facilities for the conduct of research in the sciences relating to health. The Federal share can not exceed 50 percent of the total cost of building of research space.

SCIENTIFIC STUDY SECTIONS

In view of the large number of applications which must be evaluated, and the need for skilled scientific review covering the entire range of medical and biological research, more than 30 Study Sections of special nonfederal consultants expert in various fields of research have been established. These study sections act as technical advisers to the National Advisory Councils and to the Surgeon General. They accept responsibility not only for providing technical advice on applications for research support but also in conjunction with the Councils, for surveying as scientific leaders the status of research in their particular fields in order to determine areas in which additional activity should be initiated or expanded.

TYPES OF EXTRAMURAL ACTIVITIES

The grants and awards of NIH are comprised in four main categories: (1) research grants, (2) research fellowships, (3) train-

ing grants and traineeships, and (4) health research facilities grants. I shall discuss each in a highly summary fashion, sketching their general functions.

1. Research Grants

These grants are made to universities, medical schools, hospitals, laboratories, and other public or private institutions and to individuals for support of research in health, medicine, and allied fields. The major objectives are: to expand medical and biological research in scientific institutions throughout the country; to stimulate new investigations in fields needing exploration; and to provide, incidentally, on-the-job training for scientific personnel in connection with the research being conducted. The funds provide for salaries, equipment, supplies, travel, overhead, and certain other expenses.

Research grants are financed from appropriations made to each of the seven Institutes concerned with "categorical" disease fields and from an appropriation to the NIH (for general research and services) to support needed research lying outside the "categorical" disease fields.

Grants are made on a yearly basis. However, continuity and stability, both for the work and the man, are of paramount importance and have been so considered since the beginning of the program. Therefore, the duration of the investigation is a vital consideration of the Study Sections and Advisory Councils in their decisions regarding recommendations for action. These bodies have consistently provided for continuity and have indicated to grantees continued favorable action as long as congress appropriates necessary funds. The Congress has recognized the importance of these moral commitments and has sustained them in principle and practice.

That we have steadily progressed toward greater stability is shown in the fact that, early in the life of the program, the average duration of a grant was about two years. Today, the average duration is some five years, and many meritorious investigators have received support since 1946.

Research under the program is conducted by the investigator with full independence and autonomy. Support of research through the use of research grants does not imply in any way any degree of Federal control, supervision, or direction of the research studies. Although the investigator submits a proposal in his application, he is free to pursue the project in any manner he deems most promising. The autonomy of the individual researcher implied in this philosophy does not, however, exclude self-imposed guidance entailed in the over-all plan of an organized, cooperative research project in which several groups of investigators may collaborate.

In order not to divert the time of the researcher unnecessarily from the actual conduct of the research, he is requested to submit only informal annual progress reports, and their distribution is limited to the reviewing consultants.

Neither these advisers nor those who administer the program in the NIH review grantee papers proposed for publication. Grantees, fellows, and trainees may publish results of any work supported by grant or award when and where they wish, and responsibility for direction of the work is never and should never be ascribed to the NIH, Public Health Service. This does not indicate any lack of interest in the results of research projects, but is aimed solely at avoiding any degree of governmental restriction. Grantees are requested, however, to provide 10 copies of reprints after papers have been published. It is also requested that published papers carry footnote acknowledgment of the financial assistance through the grant.

The research grants program has grown steadily. While financial figures are far from being the only factor which shows growth, they are at least easily apparent. In fiscal year 1949, some 10.8 million dollars was appropriated for the purpose; in fiscal year 1959 the appropriation for research grants is 141.5 million dollars. This year there will be some 7,000 or more research grants awards, so dispersed geographically that every corner of the country where there is real research potential will be reached and the nation will be aided with this support. Some 5,000 or so professional papers will be published by these grantees in a wide range

of journals, and it is these fruits of the work that best testify to the quality of the endeavors supported.

This is research in the public interest and in which the public is vitally interested for, as we all know, medical research is a subject which the public eagerly devours when presented through the media of public communication. Since studies done with research grants are supported with public funds, there is no desire on the part of NIH to assume credit for this work; credit belongs to the investigator and his institution and to the people who, through their Congress and Administration, make possible today so much more medical research than used to be conducted. Therefore, it is of public interest to say that, year by year, many of the medical research findings hailed in the press and among the professions have received NIH grant support. The quality of the program and the quality of the judgment exercised by the Study Sections and Councils is reflected, for example, in the fact that a total of 27 Nobelists in medicine and physiology have been recipients of NIH-PHS grant support, including this year's winners.

2. Research Fellowships

Research fellowships are intended to increase the number of scientists qualified to carry on independent research. Seven types of fellowships are presently available:

(1) *Predoctoral research fellowships* are awarded to students with a bachelor's degree or equivalent, for the pursuit of graduate research training in the fields related to the health sciences. Stipend rates are $1,600, $1,800, and $2,000 for the first, second, and third years, respectively. Allowances for dependents, travel, and tuition are added to the stipend.

(2) *Postdoctoral research fellowships* are awarded to qualified persons holding a Doctor's degree in medicine, dentistry, or related fields. Stipend rates are $3,800, $4,200, and $4,600 for the first, second, and third years, respectively. Allowances for dependents, tuition, and travel are added to the stipend.

(3) *Special research fellowships* are awarded to qualified candidates who have demonstrated unusual competence in research or who require specialized research training. The stipend, including necessary allowances, is determined at the time of the award.

(4) *Student part-time research fellowship grants* are awarded to schools of medicine, dentistry, nursing, and public health. The awards are designed to give students in the health sciences an opportunity to explore the research field in the hope that many of those supported will enter into full or part-time research careers. Units of $600 are provided for part-time research work during the school term, or for full-time research work for two months during any time when curriculum work is not scheduled for the student.

(5) *Senior research fellowship grants* are awarded to schools of medicine, dentistry, and public health in support of competent scientists who wish to conduct research and teaching in the preclinical sciences. These fellowships provide support between the completion of postdoctoral training and the time of eligibility for appointment to permanent or higher academic posts. The awards are made for 5-year periods, are renewable, and provide for salary, plus partial research expenses not exceeding $2,000. Senior Research Fellows may also apply for additional support for their research needs.

(6) *Post-sophomore research fellowship grants* are awarded to schools of medicine and dentistry for support of students who wish to obtain research training prior to completion of their professional degrees. Participants must be willing to drop out of regular courses for one, two, or three years. The stipend is set by the school in amounts not to exceed $3,200 annually. Allowances for dependents and tuition are added to the stipend.

(7) *Foreign research fellowships* are awarded to a limited number of scientists who wish to study in United States laboratories. The purpose of the program is to provide an opportunity to strengthen medical research by mutual exchange of research methods, scientific philosophy, and cultural values. Nominations will be made by respective National Research Organizations in each Western European country. Candidates must have (a) completed a doc-

toral degree in one of the medical or related sciences, and demonstrated proficiency in research, (b) made satisfactory arrangements with the laboratory in the United States where training will be obtained, and (c) acquired a workable reading and speaking knowledge of the English language. Scientists will be brought to the United States on an exchange-visitor's visa, which requires return to the homeland for a period of at least two years at the end of the training period. Stipends are $3,800 for the first year and $4,100 for the second year. Dependency, travel and certain other allowances are added to the stipend.

In fiscal year 1957, over 2,000 research fellowships were provided in a total amount of $5,300,000.

3. Training Grants and Traineeships

Training grants are intended to augment the nation's supply of qualified scientific investigators by assisting in the establishment, expansion, and improvement of training and instructional programs in universities and other institutions. Aid to the institution is provided by grants in two general classes—undergraduate and graduate.

Traineeships to individuals may be awarded either through one of the graduate training grants or directly to the individual in training. Traineeships are intended to increase the number of qualified investigators by encouraging advanced training in specialized areas of medical and related research, as well as in the fields of public health and nursing. Stipend rates vary according to the nature and requirements of the different fields covered.

(1) *Undergraduate training grants* are awarded to schools of medicine, dentistry, nursing, and public health to assist in developing expanded and better integrated undergraduate instruction relating to the prevention, diagnosis, and treatment of cancer, mental illness, and cardiovascular diseases. It is the responsibility of the institution to determine the most appropriate use of the funds.

(2) *Graduate training grants* are awarded to public and private nonprofit institutions interested in providing special training for researchers, teachers, and prospective practitioners interested in public service. Funds may be used to improve facilities and to provide salaries for faculty and staff, stipends for trainees, and necessary supplies and materials.

In fiscal year 1957, over 1,100 training grants were made in a total amount of $25,000,000. Approximately 1,950 trainees were supported under these grants. In addition, 405 direct traineeships in a total amount of $1,857,000 were made.

4. Health Research Facilities Grants

Under the Health Research Facilities Act of 1956, the Congress authorized the establishment of a program to assist in the construction of additional facilities for the conduct of research in the sciences relating to health. The program provides grants in aid on a matching basis to public and private nonprofit institutions. The amount of Federal funds awarded may not exceed 50 percent of the total costs of the research portion of the facility, and the remaining sum must be provided from non-Federal sources. The sum of $30,000,000 has been appropriated yearly for this program since its inception and to date, and meritorious applications submitted to the National Advisory Council on Health Research Facilities have requested funds far in excess of the appropriations, even though the applicants must, as indicated, match the Federal dollars. Several hundred awards have been made to institutions in all parts of the country under this program, and already new research facilities are in operation that would not otherwise have been made possible.

Here it is well to point out that the programs described above, for research, for training, and for facilities, supplement and complement each other—and help achieve the balance that always must be sought between these necessary components of research: funds for skilled investigators to do research with, facilities in which to work, and training to develop scientific manpower to do research.

In the above, I have portrayed most of the major components of the NIH extramural program. I should mention that I have not included a relatively new area for

us, that of contract research, because it is in developmental stages and is concerned largely only with the specialized area of cancer chemotherapy. Many of you, of course, know the program of our National Cancer Institute's National Cancer Chemotherapy Service Center. Through this Center a large endeavor is underway, employing contract work as one of the mechanisms, to screen many, many thousands of compounds for possible anticancer effects and to develop, ultimately and hopefully, chemotherapeutic agents useful against human cancers.

The future is bright for not only this but also the other extramural programs which I have discussed, in the opinion of the more than one thousand representatives of America's scientific community who advise upon and guide these programs. This summer a final report was issued by a group of consultants to the Secretary of the Department of Health, Education, and Welfare who had been appointed to study and advise upon the advancement of medical research and education through programs of the Department. This group, known as the Bayne-Jones Committee since it was chaired by Dr. Stanhope Bayne-Jones, foresaw and recommended a future of strong growth and development for medical and related research and medical education.

In the final analysis, of course, the continued success of the NIH program, as one of the partners in the nation's medical research enterprise, rests upon the human and economic benefits that accrue from productive scientific investigation. That the past decade has seen many such benefits, in terms of new drugs and other therapies, for example, is well known.

In the paper to which I referred earlier, presented in 1946, these thoughts were expressed:

> The great benefits from all medical research, wherever conducted, are received by the millions of people whose lives are made healthier, happier, and longer through widespread application of knowledge gained in research larboratories. Conversely, research not conducted for want of funds is very costly to the same millions. The essence of these facts, as related to the Research Grants program, has been stated by the National Advisory Health Council: "There are few purposes for which public funds could be used more appropriately than to discover ways to prevent and cure illness and to prolong useful years of life." The function of the Research Grants is to make it possible for workers in medical and allied sciences to expedite, extend, and intensify health-saving and life-saving research.

The function of the whole extramural program of NIH, comprising today 80 percent of this year's total of $324.4 million in public funds, remains essentially the same in 1958 as in 1946.

Extramural Science Programs of the United States Department of Agriculture

BY BYRON T. SHAW, *Administrator, Agricultural Research Service*

Some of the other representatives on this panel may contradict me, but I believe that the Department of Agriculture administers the oldest extramural science program in the Federal Government. We have actually had such a program since 1887. But before discussing our *extra*mural research, I want to say a few words—by way of background—about our *intra*mural or regular research program.

As you know, the Department has the responsibility in the Federal Government for agricultural research. This responsibility goes back to 1862, when the Department was established "to acquire and diffuse useful information on subjects connected with agriculture in the most general and comprehensive sense of the word." Beginning in a small way, and expanding as the needs of agriculture and the Nation increased, the Department's research program today covers all phases of production, marketing, and utilization of agricultural products. It utilizes all the life sciences, nearly all the physical sciences, and to an increasing extent the social sciences as well.

Our intramural science program is a dispersed cooperative endeavor, involving some 10,000 employees and an appropriation of approximately $90 million. We have research locations in every State, ranging in number from 1 to 28 and in size from small 1-man field stations to the large regional utilization laboratories and the Research Center at Beltsville, Md. We are also doing a limited amount of regular research in other countries—in Latin America, Europe, and Africa.

About 90 percent of our research is cooperative with other public and private organizations—including Federal and State agencies, private research institutions, and farmer and industry groups. More than half of the work is in cooperation with State agricultural experiment stations.

Through the years, the States have also provided increasing support for agricultural science. At the present time State agricultural experiment stations are spending an estimated $100 million of non-Fedreal funds for State and regional research. In addition, they are spending $31½ million made available by Congress as Federal grants. These Federal-grant funds are appropriated to the Department for payment to the States and constitute our oldest and largest *extramural* science program.

The Federal-grant program had its origin in the Hatch Act of 1887, which authorized an annual Federal grant of $15,000 to each State for the partial support of State agricultural experiment stations. Additional acts successively increased the amounts of these payments, each act setting up its own formula for distributing the funds. In 1955, Congress consolidated these acts into one statute, which now serves as the authority for all Federal-grant payments to State experiment stations.

Administration of these funds is delegated by the Secretary to the Agricultural Research Service, and we have a Deputy Administrator for Experiment Stations—Dr. E. C. Elting—who is responsible for this activity. Dr. Elting and a small scientific staff prescribe standards for Federal-grant research, approve projects to be supported by Federal-grant funds, and determine that the funds are spent in accordance with the purposes intended by Congress.

Each State experiment station director develops his own State research program in terms of State and Federal resources available to him. He submits to the ARS well-defined projects for which he proposes Federal-grant support. Projects that are approved then become an integral part of the State program and may or may not be carried out in cooperation with the Department. Publication of results and any patentable materials that may develop in Federal-grant research are entirely the property of

the State experiment station and are not subject to Federal printing or patent regulations. Close to 6,000 State experiment station projects are currently being supported entirely or in part by Federal-grant funds.

The department's role in the Federal-grant research program is primarily one of service. Although we must assure that certain legal requirements are met, a far more important responsibility is the technical assistance we're called on to give. This assistance includes comprehensive reviews of Federal-grant research, participation in planning of regional research, and coordination of research effort among the States as well as between the States and the Department. This broad review and coordinating service helps all of us to avoid duplication of effort, to recognize gaps that need to be filled, and to plan and carry out a more effective Federal-State program of agricultural research.

Our second extramural science program was initiated about 10 years ago under the Research and Marketing Act of 1946. This act for the first time gave us authority to contract for research outside the Department, when such work can be done more rapidly, more effectively, or at less cost than it can be done within the Department. Originally, this contracting authority applied only to utilization and marketing research, but in 1954 it was broadened to include all phases of Department research. At the present time, we have approximately 200 research contracts in force, totaling close to $4 million, and divided roughly fifty-fifty, in terms of public and private organizations doing the work.

I mentioned that in Federal-grant research, the States make most of the decisions. In contrast, we make most of the decisions in our contract research program. We determine what research *needs* to be done, what *will* be done, and, by mutual agreement with the contractor, *how* it will be done. In each case, we negotiate as to terms, conditions, length of time, and cost of the research to be undertaken. Research results must be published in a manner approved by the Department, and any patentable materials developed are assigned to the Secretary of Agriculture for public use.

Although, in a few cases, we have contracts involving *basic* research, it is extremely difficult—because of the very nature of basic research—to negotiate this type of contract. And we were pleased when the recent Congress, recognizing this problem, gave the Department authority, for the first time, to make discretionary grants for basic research. No special money has been appropriated for such grants, however, and our present funds are all obligated. But we hope, through future adjustments in our program, to make funds available for this purpose.

We are convinced that through both contracts and grants, we can help to obtain more efficient use of our Nation's scientific manpower and facilities and thus make faster progress in agricultural research.

The same kind of thinking is the basis of our third extramural science program, which has been initiated during the past year. This time we are undertaking—also through contract and grant arrangements—a rather extensive program of research by foreign scientists in foreign scientific institutions. Authority and funds for this work come from the Agricultural Trade Development and Assistance Act of 1954—generally called public Law 480. As you know, under this Act, our Government sells surplus agricultural commodities to foreign countries and receives payment in foreign currencies. It is these currencies that we are using for our overseas research. The Act originally limited use of these funds to research that would extend our markets for agricultural commodities. Last spring, Congress added a new authority, and we can now use Public Law 480 funds for all phases of agricultural research.

We expect to obligate something like $10 million (in foreign currency equivalent) during this fiscal year, to be spent over a period of 5 years. These obligated funds represent money now available, and they will cover the entire cost of grants and contracts negotiated. This is to assure that we will have enough money to complete any overseas research jobs that we start.

The program is being developed by three survey teams, who are visiting the various countries to evaluate the potential of their scientists and facilities and to determine the willingness of their governments to sanction the research. One team is working in Europe and the Middle East, the second in the Far East, and the third will be in Central and South America after the first of the year.

Several grants have already been executed for work in the United Kingdom and Israel, and we are well along with our negotiations in France, Italy, Spain, and Finland. Other countries—including Poland, Yugoslavia, Pakistan, Indonesia, India, and Chile—are in the survey stage. And still others will probably become eligible for participation, as additional sales of surplus products are made and additional foreign currencies become available.

Both basic and applied research, as well as developmental work, will be included in this foreign program. All basic studies will be done through grants, and all developmental work will be carried out under contract. Both grants and contracts will be used for applied research; each proposed project will be considered on its own merits.

Although no hard and fast rule has been established, we expect to concentrate the basic research in Europe, because European scientists are especially noted for their contributions in this area of research. The applied and developmental work will be done in all the countries participating in the program.

We know there is a vast reservoir of scientific manpower in the free world. And we believe, through the P. L. 480 program, that we can help to make more effective use of this manpower—to our own benefit as well as that of the countries concerned.

I want to stress that this foreign research is supplementary to our own domestic program. We are looking for institutions having scientific personnel with specialized experience and facilities that will enable them to carry out needed research more rapidly or more effectively than can now be done here in the United States.

In the utilization, marketing, and home economics research, we hope to develop new uses and new markets for agricultural products, both in the United States and in the country concerned. These studies will include quality evaluation of farm commodities, biochemical changes that occur in maturing fruits and vegetables, market disease and insect problems, and consumer habits and preferences in foreign countries.

In the farm and forestry studies, we will give special attention to foreign diseases, insects, and other pests that constitute potential threats to American agriculture. We also want to study the genetic traits of foreign livestock breeds, potential new crop plants under native conditions, and old-world soils, which may help us find out how to halt soil deterioration in this country.

Results of this overseas research will be made available to the United States public in the same way results of our domestic research are made available. And we reserve the right to publish results in other countries, including the country where the work is done, if the contractor fails to do so. All patentable materials will be assigned to the Secretary of Agriculture for United States use anywhere in the world. Rights to the use of such patents in other countries will of course be in accordance with the patent policies of those countries.

Needless to say, we are quite optimistic about this new world-wide resource for agricultural research. We believe it has great potentials for helping us solve some of our important farm problems.

Taken all together, our extramural science programs—including Federal grants to the States and the domestic and foreign contract-and-grant programs—constitute a powerful supplement to the Department's research effort. They not only represent additional manpower and facilities for getting ahead faster—they also promote better understanding and closer cooperation among all groups working to advance agriculture. And I am convinced that where we have understanding and cooperation, we have an environment for outstanding progress.

Extramural Science Programs of the Atomic Energy Commission

By CHARLES L. DUNHAM, *Director, Division of Biology and Medicine, U. S. Atomic Energy Commission*

The Atomic Energy Commission has well-defined responsibilities for the conduct of scientific research and development programs. Its science programs with the notable exception of its Health and Safety Laboratory in New York City are almost exclusively accomplished by contract and so contain practically no intramural activities in the usual sense of the word. Its national laboratories, such as the Oak Ridge National Laboratory, the Brookhaven National Laboratory, and the Argonne National Laboratory, and its other major research and development facilities such as Los Alamos Scientific Laboratory and the Ernest O. Lawrence Radiation Laboratories at Livermore and Berkeley, are largely government-owned but contractor operated, in fact, chiefly by universities or groups of universities. Exceptions are the Oak Ridge National Laboratory and the research and development activities at the Hanford Works which are under contract with industrial firms. I have assumed for purposes of this symposium that my remarks should be directed primarily toward that part of our science program carried out in non-Government owned facilities, i.e., our offsite research program.

In order to get a proper picture of our total effort, one must bear in mind that the onsite and offsite aspects of our programs are closely integrated. In general, work at the major AEC laboratories is work especially appropriate to the unique facilities and talents at hand. Interdisciplinary research and research projects involving large collaborative efforts by many scientists have proved especially effective in such an environment. This is not to say such projects can not or should not be undertaken at universities. In fact the AEC does support this type of work in its offsite programs where the situation is favorable and we have not hesitated to provide major items of equipment, building modifications and the like to universities and independent or private-owned laboratories so as to further such efforts.

Before sketching our program, and our program interests, I should give you some background.

The AEC emerged from the Manhattan Engineering District with a total monopoly in this country of nuclear-weapons research and nuclear reactor research, practically all of which was being conducted at Government-owned but contractor-operated institutions. It also found itself supporting directly or in collaboration with the Office of Naval Research a large share of the country's nuclear physics and nuclear chemistry research whether conducted at Government facilities, universities, or independent laboratories. In addition, it was supporting a program of radiobiological research. Almost all the latter was being conducted in Government-owned facilities. This was the situation at the time the Atomic Energy Act of 1946 was passed.

Section 1(a) of the Act concluded as follows: "Accordingly, it is hereby declared to be the policy of the people of the United States that, subject at all times to the paramount objective of assuring the common defense and security, the development and utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace."

The Act went on in Section 1(b) to define the purpose of the Act as follows:

> Purpose of Act—It is the purpose of this Act to effectuate the policies set out in Section 1(a) by providing, among others, for the following major programs relating to atomic energy.
>
> (1) A program of assisting and fostering private research and development to encourage maximum scientific progress;
>
> (2) A program for the control of scientific and technical information which will permit the dis-

semination of such information to encourage scientific progress, and for the sharing on a reciprocal basis of information concerning the practical industrial application of atomic energy as soon as effective and enforceable safeguards against its use for destructive purposes can be devised;

(3) A program of federally conducted research and development to assure the Government of adequate scientific and technical accomplishment.

It then went on to say that the AEC was established to accomplish these objectives. In order to implement these parts of the Act, recognizing that nuclear science and radiobiology must advance as rapidly and as free of security restrictions as possible under the Act, the AEC developed its research program in such a way as to encourage extramural research activities at universities, colleges and independent laboratories throughout the country. In the first few years of both its physical research and its biomedical research programs the AEC leaned heavily on the ONR through cooperative arrangements with that agency for rapid implementation of the program.

The reactor program continued for the most part at AEC laboratories and at AEC facilities operated by contracts with industry until the Atomic Energy Act of 1954 was passed which directed the AEC to remove from classification restrictions data whose publication and dissemination would not cause undue risk to the common defense and security. The weapons development program has continued almost exclusively in AEC installations and on a classified basis to date.

Our physical-research program exclusive of work on controlled thermonuclear reactions has grown on the basis of annual operating cost from about $21,000,000 in 1948 to about $89,000,000 in the current fiscal year. Meanwhile over and above what was inherited from the MED the AEC has spent for construction for physical research facilities more than $100,000,000, roughly three-fourths of which was spent for major research machines and associated housing, a number of which were located on university campuses. At present some $34,000,000 of the Division of Research's $89,000,000 total annual operating funds go to support work not conducted at AEC-owned major research centers. Through all its activities whether concerned with onsite or offsite research this Division shapes the programs in such a way as to foster the development of new talent for its future needs.

Work in basic physical research breaks down into four major areas: physics and mathematics, controlled thermonuclear reactions, commonly known as "Sherwood," chemistry, and metallurgy and materials.

In physics, the major effort centers around attempts to learn all that can be learned about the fundamental properties of nuclear matter through research with high energy particle accelerators as well as through the use of high flux research reactors and low energy accelerators. Although the Nation's two largest particle accelerators are located at AEC laboratories, more than one-third of the AEC funds supporting high-energy physics and nuclear structure research goes into offsite programs.

Mathematics research and research in the field of computers are sponsored for what they may contribute to advancing knowledge and in the case of computers for what these machines may contribute to a great increase in research per scientific man-year.

Work performed under the so-called Sherwood project is aimed at the development of a controlled thermonuclear reaction for the ultimate purpose of generating economic power for industrial and civilian use. This effort, currently costing between $35,000,000 and $40,000,000 annually, is limited by our present incomplete understanding of the fundamental properties of plasmas. Hence more and more work is devoted to understanding cooperative phenomena in a completely ionized gas. The major costs in this program except for the stellerator project at Princeton University are incurred at AEC laboratories.

Chemistry research includes work devoted to such very practical problems as solvent extraction and ion-exchange techniques, analytical techniques for process control and methods for producing usable amounts of rare earth salts, pure metallic uranium, thorium, zirconium, hafnium, niobium, tantalum, and the like as well as transuranic elements, all of interest to the atomic-energy program. Geochemical and geophysical research is supported princi-

pally at universities and the U. S. Geological Survey. Fundamental research in the program category "Chemical properties and reactions," with considerable emphasis on the nuclear and chemical properties of the heavy elements, takes place under heavy AEC support at universities, as well as at the AEC laboratories.

Finally, our physical research program includes heavy emphasis on metallurgy and materials. Research in this area falls into the categories of production, treatment, and properties of metals, alloy theory, and irradiation effects.

The science program of the Division of Reactor Development includes research and development activities categorized under AEC's civilian power and supporting programs and costing this fiscal year about $162,000,000. These activities are directed towards development of nuclear reactors for economic, electrical power, space heat, gasification of coal, polymerization processes, and for the propulsion of merchant vessels. This Division also administers the military reactor program which includes nuclear propulsion units for submarines, surface vessels, aircraft and rockets as well as package power units for military installations.

The civilian power program is for the most part carried out at AEC installations and at industrial establishments with some university and independent laboratory participation. The program includes not only the design and construction of research reactors and reactors for testing purposes, experimental and prototype reactors, but in addition there is a research program concerned with fuel element development, separations systems development, i.e., fuel element processing for recovery of fissionable material, radioactive waste treatment and waste disposal development, and reactor safety development.

The Atomic Energy Commission has recently inaugurated a program for accelerating the development of the industrial uses of radioisotopes. This year it will spend about $4,000,000 for applications development, high-intensity radiation studies, and to increase training opportunities for practicing industrial scientists and engineers.

In the biomedical field AEC's offsite science program is closely related to and supplements its onsite program. Of the $43,000,000 operating funds for the current fiscal year for biomedical research about one-third goes for the support of over 500 separate totally unclassified contracts with universities and independent laboratories for work in the following areas; the biological effects of the various ionizing radiations including acute and delayed effects, and effects produced by various beam intensities. Objects for study include the gamut from effects on simple biological systems to the most complex organisms including wherever possible effects on man himself. A major effort is directed to the genetic and carcinogenic effects of ionizing radiations whether from external sources or from radionuclides incorporated into the living organism. Another important area for research support is in the development of methods for altering or combatting radiation effects and for removing deposited radionuclides from the body. A third area of scientific effort is the monitoring of radioactive materials distributed around the world as fallout from nuclear weapons testing, and studies of the movement of radionuclides in the stratosphere, troposphere, the soil, plants and animals and animal products. All this is in an effort to gain an understanding of the mechanism of transport and incorporation into the food chain of these materials. The fourth category concerns work carried on at field tests, at AEC laboratories and to a lesser extent at private institutions on problems concerned with understanding and estimating effects of radiation, including radioactive fallout, thermal radiation effects and primary and secondary blast effects from nuclear weapons. A fifth category is radiation dosimetry and instrumentation. The last category we call the beneficial uses of atomic energy. Except for our cancer research program, it is very largely carried out in university laboratories and is devoted to exploiting the tools of atomic energy—reactors, and accelerators, and the byproducts of atomic energy—radioisotopes, in the advancement of knowledge in medicine, agriculture, and biology generally.

In addition to these research and develop-

ment programs the AEC science program includes training and education activities. This year we are spending approximately $15,500,000 for this purpose. We have special fellowship programs in industrial medicine, industrial hygiene, and radiological physics all carried out principally on university campuses. In addition there are reactor engineering fellowships. The training for these is partly at universities and partly at AEC laboratories. We sponsor jointly with the National Science Foundation a number of programs aimed at improving science teaching in secondary schools. This latter category includes summer workshops in radiobiology and radiological physics for high school science teachers. Finally, AEC has a program of grants for radiation equipment to be used in colleges and universities in courses in reactor engineering, courses in radiation health, and courses in the life sciences and physical sciences generally.

In summary: The AEC program in science is accomplished almost exclusively by contract with universities, groups of universities, industry, and independent laboratories. Its major operations are carried out for the most part in Government-owned facilities but contractor operated. Its offsite research involves the support of many hundred totally unclassified research projects chiefly in university laboratories and planned to supplement the work of the large laboratories. In physical science the goal is to keep the United States at the forefront in the atomic energy field. In reactor engineering—to produce economic and safe nuclear power plants for a variety of purposes.

In biology and medicine its goal is to produce as complete as possible a body of knowledge concerning the effects of ionizing radiations on biological systems and how to alter and to protect against these effects. It also aims to exploit the tools and by-products of atomic energy activities for the benefit of mankind in medicine, biology and in agricultural sciences.

Finally the AEC devotes a considerable effort to strengthening education and training in the fields of its principal interests.

Extramural Science and Research Activities of the National Aeronautics and Space Administration

By IRA H. ABBOTT, *Assistant Director of Research, NASA*

The National Aeronautics and Space Administration will be three months old in a few days. With the agency at this tender age I am certain that you will appreciate the difficulty of my speaking in detail about the nature and scope of our extramural science and education activities and the contribution made by these activities to the achievement of our objectives. We do, however, have some fairly definite thoughts and plans about these activities.

The NASA was formed with the old National Advisory Committee for Aeronautics as its nucleus. The NASA is not merely an enlarged NACA but is a new agency which includes the former NACA and other organizations which have been transfered to it. I believe it would, nevertheless, be appropriate to say a few words about the former NACA for the benefit of those of you who may not be familiar with it.

The NACA was established in 1915 to conduct research in the fields of aeronautics. Its main responsibilities were:

1. Foresight in the planning of research that would produce new research information when needed,

2. The conduct of such research, mainly in its own laboratories, and

3. Effective communication in making its research results rapidly and generally available.

The NACA fostered close contact and cooperation with other Government agencies, with industry, and with the scientific community. Its advisory committees served the

broader purpose of providing a mechanism for the exchange of scientific information and opinion, and thus encouraged the informal coordination of research through this exchange of information.

The NACA started its research activities through contracting with others for the conduct of research. In the first five years of operation, 82 technical reports were issued of which only 7 were prepared by the NACA staff, and 5 of these were in the fifth year. Through a combination of circumstances which I need not dwell upon, the NACA was unable to extend this program of contract research to meet the needs of the country, and it established its own laboratories to conduct most of its research. The total contract research program of the NACA never exceeded one million dollars a year and was usually much smaller. Even this small program was of great value in supplementing its own research because it permitted the utilization of special skills and talents that existed only in the universities and research institutions.

Because of the small size of the NACA extramural research program, the agency only occasionally sought out people or organizations to undertake research on problems proposed by itself, and limited the program to nonprofit organizations. Usually selection was made from the numerous proposals made by people who desired sponsorship for the research they wished to undertake. This system worked well for such a small program because it assured a high degree of enthusiasm and competence by the research workers. In this program the NACA operated within a rather narrow authorization. Consequently, the program was conducted with one-year fixed-price contracts. Within this limitation a sincere attempt was made to keep the program as flexible as possible. The contracts called only for work of a certain type or within an area, and a report on the results. Continuity was obtained to such a degree that a few institutions have worked continuously on certain problems for a dozen years or more.

The National Aeronautics and Space Act of 1958 creating the NASA continued all the functions of the NACA and added the direct responsibility for research in space technology, for the design, development, construction, and operation of space vehicles for peaceful purposes, and for the conduct of scientific research in space. These are grave responsibilities involving the preservation of the role of the United States as a leader in aeronautical and space science and technology.

We plan to continue our research programs at the Langley, Ames, and Lewis Research Centers to support both aeronautical and space activities. In this work we shall continue to cooperate as in the past with other Government agencies, the industry, and with educational and research institutions. With regard to our new functions in space technology, we intend to develop in our own staff a relatively small but highly skilled organization with the technical capabilities fully to meet our responsibilities in planning and conducting our programs. We expect to contract with industry for the design, development, and construction of space vehicles and components. We intend to conduct an intensive program of scientific research in space, both to assist in the development of space technology and to explore and study the natural phenomena occurring outside the earth. This program will offer unique opportunities for cooperative activity between NASA and the educational and research institutions in conducting scientific experiments using sounding rockets, satellites, deep space probes, and interplanetary vehicles.

It is obvious that the proper discharge of our responsibilities will require the full and efficient utilization of all the scientific and technical skills that should be brought to bear on this task, wherever they may exist. Consequently, the NASA plans to sponsor a greatly increased program of research in educational and research institutions. The NASA is aided in these plans by having a broad authorization for the conduct of this program. It will be under the direction of Dr. Lloyd Wood of our Headquarters staff. Our preliminary planning has established the following general principles:

1. The research may be either basic or applied

2. The research should be relevant to the mission of the NASA

3. The research should be coordinated with and supplementary to NASA Research Center programs

4. The research should be coordinated with that sponsored by the National Science Foundation and other Government agencies.

5. Continuity of support should be provided so the investigators can plan their research most effectively and make the commitments necessary to retain capable assistants.

In order to implement point 5, it is planned to make the initial obligation of funds to cover costs for periods up to three years. Insofar as practicable, notice of termination or extension of support will be given at least one year in advance. Overhead will be paid according to approved Government practices with the intent of paying the indirect cost of research activities. It is also planned to use both contracts and grants as appropriate to support the research.

It is apparent that research relevant to the mission of the NASA will include many branches of science. In addition to the usual physical and engineering sciences, we shall be interested in the cosmological sciences, the life sciences, and, at least to some degree, socio-economic studies.

I would like to emphasize the new opportunities the NASA offers for educational and research institutions to participate as full partners in the conduct of scientific research in space. The law specifically provides that one of our functions is to "arrange for participation by the scientific community in planning research measurements and observations to be made through use of aeronautical and space vehicles and conduct or arrange for the conduct of such measurements and observations."

We are confident that the educational and research institutions will be fertile sources of ideas for worth-while experiments to be conducted in space. Within the limit of our resources we shall be happy to contract with such institutions to follow up on their ideas and to reduce them to properly instrumented experiments. In some cases the engineering and operating problems may be entirely within the capabilities of the contracting institution. Such may be the case, for example, with sounding rockets. In other cases the NASA itself, either through its own resources or through industrial contracts, will necessarily play a major role in the engineering and operating phases of the program. Obvious examples would be relativistic clock experiments to study the gravitational effect and orbiting astronomical laboratories. In these cases we shall assist in such work as appropriate by arranging for instrumentation and for instrumentation packaging, by providing the vehicles, by launching and tracking them, by obtaining the data and reducing them to understandable form so that the contracting institution can analyze and interpret the information and report the results.

The coming space age is opening up vast new avenues of scientific exploration and achievement. Where they will lead I cannot say because our imaginations are too limited for us to foresee the potentials ahead. I am certain that the exploration of these avenues is a task that we must all undertake together in a spirit of scientific cooperation. We in the NASA intend to undertake our work in this spirit and to pursue it as vigorously and rapidly as will be possible with the resources made available to us.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

782D MEETING

The 782d meeting of the Society was held in the John Wesley Powell Auditorium, January 8, 1958, President CARLE H. DANE presiding.

Informal communication.—JOHN B. MERTIE, JR.: *A monazite lode in South Africa.*

Program.—HARRY KLEMIC, A. V. HEYL, A. R. TAYLOR, and JEROME STONE: *Rare earth deposit at the Scrub Oaks mine, Morris County, New Jersey.*

ISIDORE ZIETZ, G. E. ANDREASEN, and ARTHUR GRANTZ: *An aeromagnetic study of the Cook Inlet area, Alaska.*

Twenty-seven east-west aeromagnetic traverses were flown across the Cook Inlet depression at a flight elevation of approximately 2,500 feet above mean sea level. The northernmost line crosses the area between Willow and Kashwitna, and the southernmost line crosses Cook Inlet at about Homer. The lines traverse part or all of four Mesozoic tectonic elements that dominate the structure of the Cook Inlet area. These are the Talkeetna geanticline, the Matanuska geosyncline, the Seldovia geanticline, and the Chugach geosyncline.

The aeromagnetic data, compiled as total intensity magnetic profiles, show several significant features that are consistent with the structural grain of the area. A 2-dimensional anomaly is observed near the eastern edge of the area on all profiles except the southernmost lines where the feature becomes obscure. Geologic evidence strongly suggests that this feature, called the Knik Arm anomaly, is produced by granitic rocks that have been intruded along the axis of the Seldovia geanticline.

Near the western shore of Cook Inlet the magnetic pattern changes abruptly. This line of abrupt change implies a lithologic contact trending approximately northeast. This inferred contact joins the Castle Mountain high-angle reverse fault, which has been mapped along the north side of the Matanuska Valley and which separates the rocks of the Talkeetna geanticline to the north and northwest from the rocks of the Matanuska geosyncline to the south. The southern end of the inferred contact joins a similar fault. This contact, which has been named the Moquakie contact, marks the western edge of the Matanuska geosyncline; it is interpreted as a possible major fault or fault zone.

A structural basin lies between the Moquakie contact and the Chugach-Kenai Mountains. This basin is wide at the southern end of Cook Inlet and narrows to the northeast. The few anomalies over the basin area suggest depths to the basement rocks of 2 to 4 miles. A 2-dimensional, broad anomaly of about 200 gammas in magnitude trends northeast from the Richfield well, northeast of Nikishka, to the Susitna Flats area. This anomaly, called the Point Possession anomaly, is believed to be produced by a rock mass buried about three to four miles. The data suggest that this trend also continues southwest from the well.

783D MEETING

The 783d meeting of the Society was held in the John Wesley Powell Auditorium, January 22, 1958, President CARLE H. DANE presiding.

Program.—D. M. KINNEY, W. J. HAIL, JR., and A. D. ZAPP: *Latest Cretaceous and earliest Tertiary rocks between Castlegate and Green River, Utah.*

W. L. NEWMAN, A. T. MIESCH, and E. M. SHOEMAKER: *Chemical composition as a guide to the size of sandstone-type uranium deposits, Colorado Plateau.* Concentrations of uranium, yttrium, sodium, iron, zirconium, manganese, calcium, and nickel in 75 mill pulp samples of uranium deposits in the Salt Wash member of the Morrison formation on the Colorado Plateau seem to be significantly related to the sizes of the deposits represented by the samples. Linear correlation coefficients between element concentrations, as determined by semiquantitative spectrographic analysis, and sizes of deposits in tons, range from /0.37/ for uranium and yttrium to /0.24/ for nickel. The lowest significant correlation coefficient for the 75 samples at the 95 percent level of confidence is 0.228. Three methods of size estimation were developed: one based on simple linear regression theory and two based on multiple regression theory. About 80 percent of the size estimates based on simple linear regression theory are within a factor of 12 to 14 of the true size. Estimates based upon multiple regression theory range within approxi-

mately the same orders of magnitude. Although the error of the estimates may be quite large, the methods permit classification of the deposits within reasonable confidence limits into the following size groups: very large deposits (10,000 to more than 100,000 tons), large deposits (1,000 to 10,000 tons), medium deposits (100 to 1,000 tons), small deposits (10 to 100 tons), and very small deposits (1 to 10 tons). These methods will be useful in estimating the sizes of deposits where exposures of ore are limited, or where an estimate is desired that is independent of other estimates.

CHARLES MILTON, MARY E. MROSE, and E. C. T. CHAO: *Recent developments on the mineralogy of the Green River shales.*

784TH MEETING

The 784th meeting of the Society was held in the John Wesley Powell Auditorium, February 12, 1958, President CARLE H. DANE presiding.

Informal communication.—PRESTON CLOUD: *Mode of locomotion of an Upper Cambrian trilobite.*

Program.—RALPH L. MILLER: *Faulting in the southern Appalachians.* DAVID M. RAUP: *The effect of environment on echinoid morphology.* The scutellid echinoid genus *Dendraster* L. Agassiz has a geologic range from Pliocene to Recent. Sand-dollars of this genus live now from central Baja California to Vancouver Island, British Columbia. Fossils occur in central and southern California and in Baja California. In the past, *Dendraster* has been classified into 25 species, subspecies, and varieties. In all these forms, the apical system is posteriorly eccentric. Variations in the eccentricity of the apical system figure prominently in approximately two out of every three taxonomic distinctions within the genus.

The position of the apical system in *D. excentricus* (Eschscholtz) varies widely. Variation in this character between adjacent populations of this single living species often exceeds variation between species in the fossil record. Furthermore, variation in the eccentricity of the apical system in *D. excentricus* is correlated with water turbulence. In areas of high water turbulence, such as those just beyond the surf zone along the exposed coast, sand-dollars of this species exhibit high eccentricity; that is, the apical system is located near the posterior margin of the test. In quiet water, whether it be at depth along the exposed coast or in shallow protected bays, sand-dollars have a nearly centered apical system (low eccentricity). In intermediate environments, intermediate morphology obtains. The correlation between turbulence and morphology is interpreted as nongenetic variation (nonheritable) resulting from the effect of environmental forces. The high degree of eccentricity enables sand-dollars living under turbulent conditions to be stable in the feeding position and still have the madreporite exposed (in the feeding position, they are inclined to the sea bottom with the anterior portion of the test buried).

Variation in eccentricity in fossil *Dendraster* is interpreted in light of the above findings. The three prominent Pliocene species, *D. coalingaensis* Twitchell, *D. ashleyi* (Arnold), and *D. gibbsii* (Rémond), have previously been distinguished from each other partially on the basis of this character. Statistical analysis of these forms shows *D. ashleyi* and *D. gibbsii* to be indistinguishable on the basis of this character. Further, the amount of difference in eccentricity between *D. coalingaensis* and *D. gibbsii–D. ashleyi* is of the same order of magnitude as that between populations of the living species occurring under conditions of differing water turbulence. Thus, the eccentricity differences between *D. coalingaensis* and *D. gibbsii–D. ashleyi* are interpreted as the result of differing water turbulence and not genetic change. This does not mean that the three species are synonymous but only that the differences in eccentricity are not genetic. The mean eccentricity of the three Pliocene forms, on the other hand, is greater than that of the living species, *D. excentricus*. Thus, there appears to have been evolution toward a less eccentric apical system between Pliocene and Recent.

Therefore, the eccentricity of the apical system shows genetic change over time whereas at a given point in time, it shows non-genetic change and hence is an indicator of past environmental conditions.

R. A. BAGNOLD: *Correlation between wind and sand-dune directions in the light of present-day conditions.*

785TH MEETING

The 785th meeting of the Society was held in the John Wesley Powell Auditorium, Febru-

ary 26, 1958, Vice-President LLOYD G. HENBEST presiding.

Program.—JOHN C. REED, JR.: *Crystalline rocks of the Potomac River Gorge near Washington, D. C.* Below Great Falls, about 10 miles northwest of Washington, the Potomac River is entrenched in a spectacular gorge which affords unexcelled exposures of the crystalline rocks of the Piedmont. The major rock types exposed between Great Falls and Stubblefield Falls are: (1) Mica schist and arkosic quartzite, assigned by Keith (1901) to the Carolina gneiss, and by Cloos (1953) to the Wissahickon formation, (2) amphibolite bodies, probably representing sills or lava flows, interlayered in the schist and quartzite sequence, (3) granitized schist (in part the Sykesville formation of Cloos, 1953), and (4) sodic quartz diorite or granodiorite in small discordant intrusive bodies. The age of the rocks is problematical: the quartzite-schist sequence has been considered by some geologists to be Precambrian, and by others to be an eastern metamorphosed equivalent of lower Paleozoic rocks in the Blue Ridge.

The quartzite occurs in massive beds as much as 40 feet thick, and as thinner beds, commonly regularly interlayered with schist. Locally, graded bedding and crossbedding are preserved. Bedding in the schist has been largely obliterated, and the only conspicuous planar structures are sets of S-planes marked by parallel orientation of micaceous minerals. The earliest of these is parallel to bedding in the associated quartzites, whereas the younger set is subparallel to axial planes of folds. Locally the axial plane cleavage is a closely spaced slip or fracture cleavage, but generally it is marked by a parallelism of new micas. In many places formation of the new cleavage has destroyed all trace of the older bedding plane foliation.

Petrographic evidence indicates that the quartzite-schist sequence has undergone at least two periods of metamorphism. Large bent and ragged books of biotite and muscovite, very rare relicts of andalusite, and indeterminate sericite pseudomorphs, probably after andalusite or other aluminum silicate minerals, are believed to be relicts of the early stage. During the later metamorphism new biotite, muscovite, and garnet were formed, and the earlier aluminum silicates were almost completely altered to sericite. In the interlayered mafic rocks the earlier metamorphism produced the assemblage andesine-green hornblende-clinozoisite, which during the later metamorphism was locally converted to an assemblage of oligoclase-epidote-biotite with green hornblende as a relict. Perhaps these two metamorphic episodes can be correlated with the formation of the two sets of S-planes in the schist.

The granitized schist was apparently produced by interaction of the normal schist with soda-rich solutions, probably at a late stage in the second metamorphic cycle. All gradations exist between schist with thin oligoclase-quartz filaments along the two sets of S-planes to rocks in which thin micaceous wisps, still preserving the orientation and relationships of the S-planes in the adjacent schist, appear "suspended" in a granitic matrix of quartz and oligoclase.

Field relationships indicate that small discordant plugs and dikes of leucocratic quartz diorite, identical in mineralogy with the quartz-feldspathic components of the granitized schist, may represent local intrusion of material derived from the granitized schist. Small granitic bodies may have originated by migration of material into regions of low pressure near brittle amphibolites and quartzites, while still others may have been formed entirely by metosomatic replacement.

It is hoped that this brief outline will encourage others to continue studies in this easily accessible and extremely well exposed area.

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F. G. HOUTERMANS: *Effects of cosmic radiation in meteorites and the earth's atmosphere.*

786TH MEETING

The 786th meeting of the Society was held in the John Wesley Powell Auditorium, March 12, 1958, President CARLE H. DANE presiding.

Communication.—JOHN B. MERTIE: *A memorial to Fred H. Moffit.*

Program.—U. S. Geological Survey investigations at the Nevada test site: E. B. ECKEL and C. B. READ: Geological phase; W. H. DIMENT and others: Geophysical phase.

787TH MEETING

The 787th meeting of the Society was held in the John Wesley Powell Auditorium, March 26, 1958, President CARLE H. DANE presiding.

Program.—M. GORDON WOLMAN and LUCIEN M. BRUSH, JR.: *Laboratory study of equilibrium channel shape in noncohesive material.*

J. T. HACK: *The relation of manganese to surficial deposits in the Shenandoah Valley, Virginia.* Manganese mines and prospects in a narrow zone at the northwest foot of the Blue Ridge occur in residual clays of the Cambrian Tomstown dolomite and Waynesboro formation. They are covered by a mantle of quartzite cobbles washed from the mountain slopes. The deposits are thought by some to have formed on the Harrisburg peneplain in Tertiary time under conditions of lesser relief and warmer climate, as residual concentrates from carbonate rocks.

Mapping of the surficial deposits of the Shenandoah Valley reveals no evidence to support the concept of multiple erosion cycles or of a valley floor peneplain that might have provided a site for manganese concentration. The features of the region are better explained as the result of long-continued and deep erosion of a folded area that is now close to isostatic equilibrium. Alluvium occurs where streams enter the limestone valley from areas of resistant sandstone and quartzite and is spread by laterally migrating and degrading streams that form pediment-like aprons near the mountain foot. The spreading is aided by piracies of the main streams by their own tributaries. Residuum, or saprolite, occurs on limestone where the insoluble residues are protected from erosion by a resistant capping of either transported gravel or of coarse-grained chert residual from the limestone itself.

The manganese deposits are residual concentrates in the clay, preserved not because they are uneroded remnants on a Tertiary surface but because they have been formed under an armor of alluvial cobbles and gravel. The process of manganese concentration is a continuous one and may possibly be going on at the present time.

EARL INGERSON: *The Moscow symposium on petrochemistry, December 1957.*

788TH MEETING

The 788th meeting of the Society was held in the John Wesley Powell Auditorium, April 9, 1958, President CARLE H. DANE presiding.

Program.—G. W. WETHERILL, G. R. TILTON, and G. L. DAVIS: *Age of the Baltimore gneiss.*

DAVID LANDEN: *New developments in photogrammetric measurements for geologists.* One of the recent developments in the Geological Survey has been the introduction and use of modern photogrammetric mapping equipment in geologic investigations. While aerial photographs have long been one of the most important tools of the geologist, the use of modern double-projection stereoscopic plotting equipment has taken place only within the last few years. As a result of recurring problems which concerned the application of photogrammetric techniques to geologic mapping, the chief topographic engineer and the chief geologist in 1953 formed an Interdivision Committee on Photogrammetric Techniques in Geology. This group cut across the lines of the largest Divisions in the Survey and soon became a potent force in the advancement of photogrammetry in geology through instrument development, training, publications, and technical assistance.

Advances in the design and use of stereoscopes, simple photogrammetric measuring equipment, and the use of modern double-projection plotting equipment such as the Multiplex, Kelsh, and ER-55 for geologic use are described. Several new instruments, useful for making measurements under a stereoscopic plotter, were sponsored by the Interdivision Committee; these included the photogrammetric profile plotter, the photogrammetric dip-and-strike indicator, and others. The stereoplotted grid was designed to facilitate transfer of geologic data from photograph to map. The orthophotoscope machine and its product, the orthophotograph, were developed primarily for geologic use. The orthophotograph is a photograph in which essential detail has been rectified to an orthographic, or plan, projection. It has become today one of the great advances in surveying and mapping technology. A new photographic technique, useful to paleontologists, was also developed—photographs of fossils in orthographic projection.

It is concluded that one of the best means of advancing a science such as geology is to advance

its measuring and mapping techniques. Aerial photographs and photogrammetry, by their very nature, should be among the geologist's most fundamental operations—that of making accurate measurements.

VINCENT C. KELLEY: *Structure and fracture systems of the Colorado Plateau.* The Colorado Plateau is a relatively undeformed structural segment within the Cordilleran orogenic systems. It consists of irregularly interspersed uplifts, basins, platforms, and lesser fold belts of mild or moderate intensity. Most of the deformation, however, is concentrated along great monoclinal flexes which bound certain parts of the uplifts and basins.

Fracture sets have been mapped on a scale of 1:62,500 on photomosaics for a large part of the Plateau. The joint sets range greatly in stratigraphic and areal extent, in spacing, in orientation, and in numbers. Dominant joint sets are nearly vertical in areas of low-dipping rocks, but inclined longitudinal and oblique joint sets are common along monoclinal flexes. From this relationship and from the fact that the fracture systems reveal little regular relationship to folds in most places, it is concluded that many of the sets are older than the Laramide folding. Some, however, are clearly younger than the principal folding.

The fracture systems of the several major uplifts are largely dissimilar. The lack of similarity of uplift fracture patterns may be due to (1) differences in the uplift forms and their regional settings, (2) differences in stratigraphy, (3) differences in rate and manner of uplift growth, and (4) the fact that many of the sets appear by areal distribution to be related to crustal disturbances of much greater extent than the uplifts and of quite different mechanics of deformation.

Numerous joints probably formed early for nonorogenic reasons such as differential compaction, differential loading, original-dip gliding, and epeirogenic warping. Nevertheless, the existence of some consistency of orientation of dominant regional sets in northeasterly, northwesterly, and easterly directions makes it appear that there were over-all deep-seated stress systems, responsible, in complicated ways, for many of gross aspects of the fracture pattern.

Three east-west lineaments of fracture zones, the Cache Valley, Rico, and Rattlesnake, are "rooted" in part in the Precambrian structures to the east and are thought to be reflections of shearing before and during Laramide in the basement.

Two phases of Laramide deformation on the Plateau are postulated. The first resulted from a major stress oriented easterly or southeasterly which formed the northerly and northeasterly trending monoclines. The second phase resulted from a major regional stress oriented southwesterly which formed the northwesterly trending folds and uplifts.

789TH MEETING

The 789th meeting of the Society was held in the John Wesley Powell Auditorium, April 23, 1958, President CARLE H. DANE presiding.

Informal communications: EDWIN ROEDDER reported on the Science Fair held in Georgetown on April 19, at which he had been a judge, and introduced a prize winner, Philip Perkins.

L. T. ALDRICH reported the seismic detection in the Washington area and in New York State of the Ripple Rock blast in the Seymour Narrows, British Columbia.

Program.—GORDON E. ANDREASEN, ISIDORE ZIETZ, and ARTHUR GRANTZ: *Structural interpretation of aeromagnetic data observed in the Copper River Basin, Alaska.*

Z. S. ALTSCHULER and E. J. YOUNG: *Relations between Tertiary sedimentation and structural history in west-central Florida.*

RICHARD H. JAHNS and C. WAYNE BURNHAM: *Preliminary experimental evidence on pegmatite crystallization.*

790TH MEETING

The 790th meeting of the Society was held in the John Wesley Powell Auditorium, October 8, 1958, President CARLE H. DANE presiding.

Program.—The deferred presidential address of W. D. JOHNSTON, JR.: *Outside Interior, or the Geological Survey's part in foreign technical assistance, 1940–1958.*

791ST MEETING

The 791st meeting of the Society was held in the John Wesley Powell Auditorium, October 22, 1958, President CARLE H. DANE presiding.

Program.—ADRIAN RICHARDS: *Eruption of Capelinhos Volcano, Faial Island, Azores, a report of the Cranbrook Expedition, 1958.*

IRVING FRIEDMAN: *Deuterium and the age of Arctic sea ice.* The deuterium fractionation that

occurs upon the change of state of liquid water to ice has been measured under natural conditions. The ice is enriched in deuterium by 2 percent relative to the water in equilibrium with it.

Consecutive samples from an ice-core collected near ice island T-3 (80°N, 113°W) was analyzed for its relative deuterium content. A plot of relative deuterium content versus depth in the 10-foot core shows several minima. These minima are interpreted to be due to the freezing of snow melt water that runs off the surface of the ice in summer. If this thesis is correct, the ice flow represents the accumulation of 4 years of winter ice.

D. F. HEWETT: *Deposits of the manganese oxides.* The program of field work on manganese deposits during the war permitted the collection of many specimens of manganese oxides over the entire nation as well as in Cuba and Mexico. X-ray analyses of about 250 specimens from the United States, 150 specimens from Cuba, and 100 from Mexico have been made by Richmond and Axelrod of the Geological Survey to determine mineral character, and partial and complete chemical analyses have been made of many specimens by Fleischer of the Survey. Some of the results of this work have been announced by Fleischer and Richmond. Recently, Hewett has continued the study of the manganese oxides by interpreting the geological environment under which the 250 specimens from the United States were formed.

From this review of the mode of occurrence of the oxides of manganese, 33 in number of which 27 are known in the United States, the conclusion has been reached that (1) some of the oxides are uniformly supergene throughout the United States, (2) another group is uniformly hypogene, and (3) another group that includes the common oxides, psilomelane, hollandite, cryptomelane, coronadite, hetaerolite and pyrolusite, is supergene in some places and hypogene in others. To reach this conclusion, a group of criteria to distinguish between supergene and hypogene origin was set up.

The study indicates that in the broad arc from central New Mexico across Arizona into southern California and Nevada there are many veins of the manganese oxides, at least 100, of which at least 30 are extensively explored, largely made up of psilomelane, hollandite with minor cryptomelane, coronadite, and pyrolusite, which are hypogene in origin. Most of the veins follow fractures and breccia zones in layered volcanic rocks of middle Tertiary age. Associated with the manganese oxides, in some places younger and in other places older, are opal, chalcedony, quartz, zeolites, fluorite, barite, and calcite, in part hydrothermal in origin. In the same broad arc there are numerous deposits of stratified manganese oxides which contain small but noteworthy amounts of tungsten, lead, and copper, which are also found in the vein oxides. It is concluded that the veins of oxides are related to the stratified oxides; that hot waters from depth contained manganese which was deposited as oxides in the veins where the solutions met the shallow zone of ground water containing oxygen. The remaining manganese was carried to the surface where flocculent oxides were formed and carried as sediments to nearby basins. This interpretation is supported by the presence in the region of hot springs that are now depositing oxides of manganese that contain the same minor metals as the veins and stratified oxides.

792D MEETING

The 792d meeting of the Society was held jointly with the Paleontological Society of Washington in the John Wesley Powell Auditorium, November 12, 1958, Vice-President ALICE ALLEN presiding.

Program.—ALFRED S. ROMER: *Rocks, fossils, and Darwin.*

793D MEETING

The 793d meeting of the Society was held in the John Wesley Powell Auditorium, December 10, 1958, Vice-President LLOYD G. HENBEST presiding.

Program.—The Presidential address; CARLE H. DANE: *The New Mexico geologic map—a summary of 30 years of geologic progress.* Preliminary versions of the geology of the northwestern and southeastern parts of New Mexico, by Carle H. Dane and George O. Bachman, have been published by the U. S. Geological Survey, and first compilation has been completed for the remainder of the State. These preliminary maps were assembled and exhibited as a new summary picture of the geology of New Mexico, 30 years subsequent to the issuance of the previous U. S. Geological Survey geologic map of New Mexico by N. H. Darton. The new map will show many more geologic units than were

previously recognized, hundreds of faults and intrusive dikes not previously shown, and much greater detail of geology, summarized from more than 150 different sources of data, published and unpublished. During the 30-year interval between the two maps, vertical air photographic coverage of the whole State has become available, and the reconnaissance and semidetailed phase of geologic mapping of the State has been nearly completed. During this interval the concepts of intertonguing and of facies changes have become firmly established in geologic thinking, in part as a result of detailed studies of the Permian, Cretaceous, and Tertiary rocks in New Mexico, and these concepts are reflected in the new map.

The general geology of the State was briefly described with particular reference to the distribution of units selected for discrimination on the compilation, and the geology of six selected areas was described more fully to illustrate the more detailed geologic mapping that is now available for generalization and to show the variety of sources from which data was derived. Some new facts about the geology of the State discovered in recent years and during reconnaissance in connection with the State map project were mentioned. The excellent record of geologic assistance and guidance in the discovery and development of mineral resources in New Mexico was summarized, and it was pointed out that the annual value of production of mineral resources in the State has increased more than tenfold in the last 30 years, due chiefly to spectacular increases in the value of oil and gas, potash, and uranium produced. The geologist has thus made a substantial contribution to the improvement of the general welfare in the State.

66TH ANNUAL MEETING

The 66th annual meeting was held immediately following the 793d meeting, President CARLE H. DANE presiding. The reports of the secretaries, treasurer, and auditing committee were read and approved. The Awards Committee presented first prize to G. W. WETHERILL, G. R. TILTON, and G. L. DAVIS for their paper *Age of the Baltimore gneiss* and second prize to ISIDORE ZIETZ, G. E. ANDREASEN, and ARTHUR GRANTZ for their paper *Aeromagnetic study of Cook Inlet, Alaska*. The Sleeping Bear Cup was presented to W. H. BRADLEY for his devastating demolition of a special Cloud effect.

Officers for the year 1959 were then elected:

President: JOSEPH W. GREIG
First Vice-President: CHARLES A. ANDERSON
Second Vice-President: LOUIS C. CONANT
Secretary (2 years): J. THOMAS DUTRO
Treasurer: HELEN F. WEISSENBORN
Members-at-large of the Council (2 years): CHARLES S. DENNY, JOHN E. JOHNSON, ROBERT C. STEPHENSON.

The Society nominated CARLE H. DANE to be a Vice-president of the Washington Academy of Sciences for the year 1959.

If our scholars would lead more earnest lives, we should not witness those lame conclusions to their ill-sown discourses, but their sentences would pass over the ground like loaded rollers, and not mere hollow and wooden ones, to press in the seed and make it germinate.—THOREAU.